Weatherwise

The Origin and Detection of Hurricanes

Flood Disaster in Kansas

The Annular Eclipse of September 12

Increasing Precipitation Through Cloud Seeding

Halos

Vol. 4, No. 4, August, 1951

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE" — BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

COPYRIGHT 1951, BY AMATEUR WEATHERMEN OF AMERICA

DAVID M. LUDLUM, *Director* — CHARLES A. FEDERER, JR., *Editor*
HANS H. NEUBERGER, *Technical Editor* — D. C. CAMERON, *Research Associate*
ERIC SLOANE, *Art Director*

ECLIPSE WEATHER BROADCASTS

On August 31st, 10:45 to 11:00 p.m. EST, I shall do a broadcast over Station WTAR, Norfolk, Va., on 790 kilocycles. The broadcast will cover 10:30 p.m. weather conditions over the eclipse path and probable conditions at sunrise of September 1st. A story on the eclipse will also be contained in the broadcast.

Also, I expect to do a last-minute roundup on weather conditions as of 4:30 a.m. September 1st, over WRVA, Richmond, Va., on 1140 kilocycles. This broadcast will be near 5:00 a.m. and will originate in a Norfolk studio if I do it, but there is some possibility that it may be direct from the Weather Bureau Airport Station, Byrd Field, Richmond.

AUBREY HUSTEAD
USWB, Norfolk, Va.

For the annular eclipse of the sun September 1st, we are arranging for special weather broadcasts from the Weather Bureau office in Winston-Salem, N. C. These broadcasts will be given in co-operation with Station WSJS, Winston-Salem, on 600 kilocycles in the regular broadcast band and at 104.1 megacycles on FM. Reports over this station may be heard within a radius of 60 to 75 miles of Winston-Salem, and even farther at times, especially early in the morning.

A regular weather broadcast will be given at 6:06 p.m. EST, August 31st, followed by a special weather broadcast at 11:05 p.m. Another special broadcast will be given at 5:05 a.m. EST on Saturday, September 1st. On these broadcasts we shall include the state of the sky (whether cloudy, clear, and so forth), and the possible chance for obtaining a view of the eclipse at the following stations: Winston-Salem, N. C.; Greensboro, N. C.; Raleigh-Durham-Chapel Hill, N. C.; Elizabeth City, N. C.; Danville, Va.; Norfolk, Va.; Pulaski, Va.; and Richmond, Va. Also, sky conditions will be given at other places within the eclipse area, if obtainable.

Amateur weathermen at locations other than the above-named cities can render a great service by calling the Weather Bureau, Tel. 3-2250, Winston-Salem, between 4:30 a.m. and 4:55 a.m. September 1st and reporting the sky condition. The observer must pay for these calls, which cannot be made collect. This latest information will be broadcast on the 5:05 a.m. report. This will give an eclipse observer 50 minutes to move to a nearby location that may have clearer skies or better prospects of clearing. We would particularly appreciate a call from some observer at Pilot Mountain.

WILEY K. SIMS
Official-in-Charge
USWB, Winston-Salem, N. C.

Vol. 4, No. 4 — August, 1951

CONTENTS

The Origin and Detection of Hurricanes — Major Newton M. Burgner 75
Flood Disaster in Kansas 79
Halos — Hans H. Neuberger 80
The Annular Eclipse of September 1st 84
Increasing Precipitation Through Cloud Seeding — Robert D. Elliott 88
A Record June Snowstorm at Calgary, Alberta — A. F. McQuarrie and C. Pickering 91
551.5 92
Workshop for Weathermen — Charles A. Laird 93

Cover: An Air Weather Service B-29, from the 373rd Reconnaissance Squadron, Kindley Air Force Base, Bermuda, has just completed routine tracking of a hurricane. Wheels and flaps are let down in preparation for an instrument landing. Official photograph, National Military Establishment.

WEATHERWISE is published bimonthly by Amateur Weathermen of America, Franklin Institute, Philadelphia 3, Pa. Membership in the AWA costs $3.00 per year, of which $2.00 is for a subscription to WEATHERWISE and $1.00 for general dues, for members in the United States and possessions and in the armed services. Add 50 cents per annum for postage to Canada and all countries of the Pan-American Postal Union; add $1.00 for all other foreign countries. Make checks and money orders payable to Amateur Weathermen of America. Send notice of change of address three weeks in advance, giving old address. General, circulation, and advertising offices: Franklin Institute, Phila. 3, Pa.

A Military Air Transport Service photograph of the eye of the typhoon "Gloria," off Okinawa, July, 1949, at an altitude of 10,500 feet. On either side of the aircraft was a bank of towering cumulus reaching to 35,000 feet. Below were broken to scattered stratocumulus associated with fractocumulus. The light by which the picture was taken is coming down through the upper part of the eye. The clouds below cover the lower part of the eye so the ocean surface cannot be seen clearly. The darkness on the right is caused by the cumulonimbus wall of the typhoon. U. S. Air Force photograph.

The Origin and Detection of Hurricanes

MAJOR NEWTON M. BURGNER, HEADQUARTERS, AIR WEATHER SERVICE

SIGNIFICANT progress has been made in understanding hurricane movement and the synoptic factors that influence the paths of tropical storms. In recent years, the importance of considering the broad-scale weather pattern in relation to hurricane movement has been emphasized. It has become clear that better methods of forecasting the general synoptic situation will provide more accurate forecasts of storm movement.

The internal hurricane forces have also been investigated, and meteorologists have found that oscillatory and irregular paths are quite common. Such studies have helped to explain why reliable navigational fixes have given seemingly erratic tracks for storms. The path of a hurricane is not necessarily a smooth, regular curve.

Success in solving the problem of hurricane formation has been less rapid. Some progress has been made recently, however, from an empirical standpoint. The upsurge of progress in tropical meteorology has been a direct result of operational requirements created by World War II. The Air Force, in cooperation with the University of Chicago, es-

tablished the Institute of Tropical Meteorology at Puerto Rico in 1943 to attack the problem, and successful research on tropical weather was accomplished. The study of hurricanes has been continued since the war at the University of Chicago, with Navy co-operation, under the guidance of Dr. Herbert Riehl.

Hurricane Formation

For more than 100 years, meteorologists have realized that hurricanes and typhoons developed over warm ocean waters. They noticed that such storms did not form over those parts of the oceans where the water was cold. Observers concluded that warm temperatures and great amounts of moisture were needed for tropical storm formation. The thermal or convective theory of hurricane origin evolved from this idea, and claimed that these tropical storms were really overgrown thunderstorms. On the other hand, certain meteorologists pointed out that, although there was no limit to such convective activity in the tropics, the hurricane season was definitely limited.

Opponents of the thermal theory during the late 19th and early 20th centuries stated that the principal wind systems and their interactions were the main causes of hurricane formation. Some meteorologists tried to combine this concept with the thermal theory, maintaining that the cause of a tropical storm was the counter-current reaction which initiated the cyclonic center, while the convective theory accounted for its maintenance after the storm had started.

After World War I, there was an immediate attempt to use the new polar front theory to solve the problem of hurricane origin. The period 1920-1940 saw the publication of much literature on this subject, with attacks and defenses and attempts again to combine features of the various theories.

It now appears that a tropical storm does not form as an overgrown convection cell or from frontal conditions. It develops from a pre-existing tropical disturbance. This may be a trough, wave, or shear line, but some such cyclonic element seems to be required for hurricane formation.

Most of the common tropical disturbances are of a stable nature, producing well-known patterns of tropical weather. There must be some additional factor that causes intensification of such a tropical disturbance to hurricane strength. The synoptic indicator of such intensification appears to be the interaction of two or more cyclonic disturbances. Such interaction may be by relative motion:

1. Between high and middle latitudes, or
2. Between high and low levels within the tropics.

An easterly wave in the tropical trades and an upper-level trough in the middle-latitude westerlies usually comprise the first of these patterns. The second type of interaction, between concurrent cyclonic disturbances at low and high levels in the tropics, is more common in the Pacific than in the Atlantic, although it occurs in both regions.

The fact that the upper-level flow of the tropics is extremely unsteady compared to that of the low-level trades has an interesting association with middle-latitude conditions. While the well-known trade winds of the tropics have practically constant direction with height between the surface and roughly 20,000 feet, the high tropospheric layer between 25,000 and 45,000 feet is characterized by large cyclonic and anticyclonic circulations. The extratropical region, on the other hand, has unsteady air flow with vortices located in the lower levels, while in the higher troposphere the steadier zonal westerlies prevail. With these opposed patterns existing between low and high tropical altitudes and between tropical and extratropical latitudes, interaction of cyclonic disturbances by relative motion becomes possible under certain conditions.

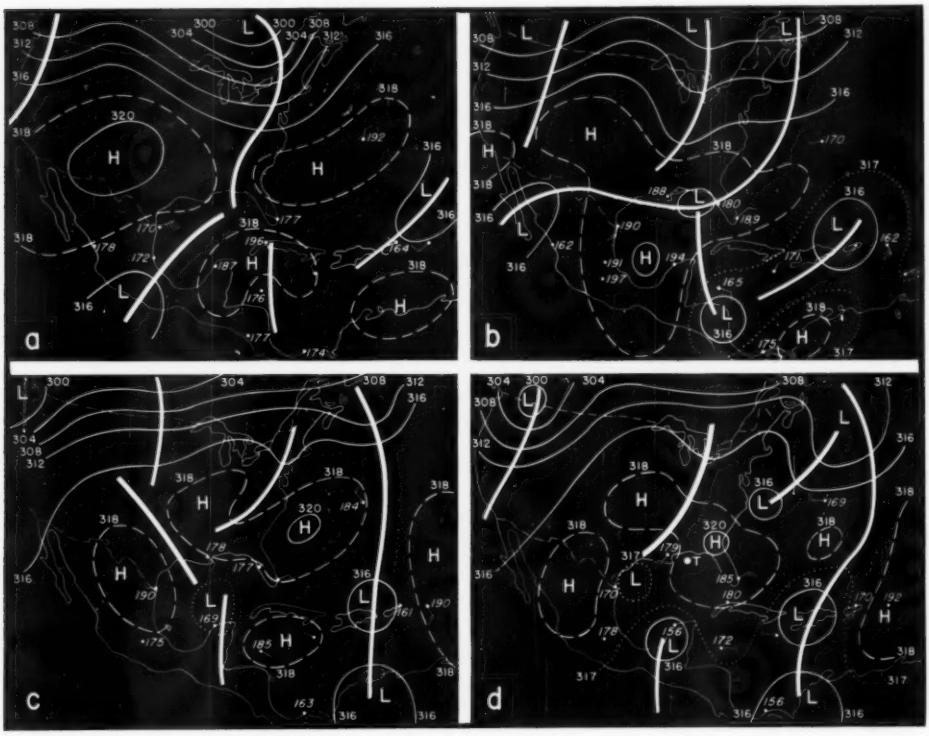
The typical pattern of superposition which causes cyclonic intensification consists of westerlies far to the north and the formation of an extended trough from the westerlies into the trades. Then, as the high-latitude portion of the trough moves through to the east, the southern part of the trough breaks off or "fractures." If the polar westerlies overlie the tropical easterlies, there will be great stability, and tropical disturbances cannot intensify.

Cyclonic superposition can produce winds up to 25 miles per hour, heavy rains, but no hurricane. One of the synoptic models found to be associated with intensification to hurricane strength calls for the relative motion that produces cyclonic superposition to continue, so that high-level anticyclonic condi-

tions move in over the intensified low-level cyclone. For the storm to retain hurricane intensity, it is believed that high-level anticyclonic divergence must persist over the storm. However, there appear to be tropical storms that do not wholly fit this model. Such storms are associated with cyclonic conditions at high levels. Nevertheless, many hurricanes and typhoons have been found with anticyclones located above the low-level cyclonic circulation, and this feature must be considered in the development of hurricane models. Further research and study are necessary on this phase of the problem.

Since extended troughs associated with tropical storm formation usually involve major troughs in the long-wave train in the westerlies, it is unlikely that a tropical disturbance formed by superposition will deepen when the long waves are stationary. Intensification is most common during movement of the long waves in the westerlies.

The situation of September 6-8, 1947, illustrates these principles. The location of this storm in the Gulf of Mexico was particularly convenient for taking observations. At the surface there were several days of disturbed weather conditions as two high-latitude troughs moved through and superimposed on an easterly wave that had moved into the area. The storm developed as the trough broke off and the ridge aloft moved over the lower



These are 300-mb charts for 0400 GCT on September 3, 5, 7, and 8, 1947, respectively. The contour heights are in hundreds of feet: solid lines for 400-foot intervals, broken lines, 200-foot, and dotted lines, 100-foot intervals. The heavy solid lines indicate trough positions. The tropical storm surface position is marked by "T" on chart d. The eastward movement of the high-latitude troughs off the East Coast and over the eastern United States on the 5th (b), with the formation of an extended trough into the low over Central America, continued, causing fracture of the trough by the 7th (c). The northern portion of the trough moved out over the Atlantic Ocean while the southern part moved westward. The cyclone at the surface intensified as the anticyclone moved over it on the 8th (d). Air Weather Service chart.

disturbance. The four charts on the preceding page show the movement in the long-wave pattern of the westerlies, formation and fracture of the extended trough, and intensification as the anticyclone moved over the surface disturbance.

By the same principle, movement of a low-level disturbance underneath a stagnating upper ridge is not favorable for deepening. Such a situation took place during June and July, 1949. Several small centers formed both east and west of Florida, while an upper ridge persisted over the eastern United States. None of the vortices was able to develop to hurricane strength.

Important synoptic factors in hurricane formation appear to be:

1. Warm ocean with associated high temperature and moisture in the atmosphere.
2. Pre-existing low-latitude disturbance.
3. Cyclonic superposition of: a. High-level extratropical and low-level tropical. b. High- and low-level tropical with exclusion of the influence of the westerlies.
4. High-level anticyclonic superposition on an intensified low-level cyclone.
5. Dynamic relative motion producing 3 and 4.

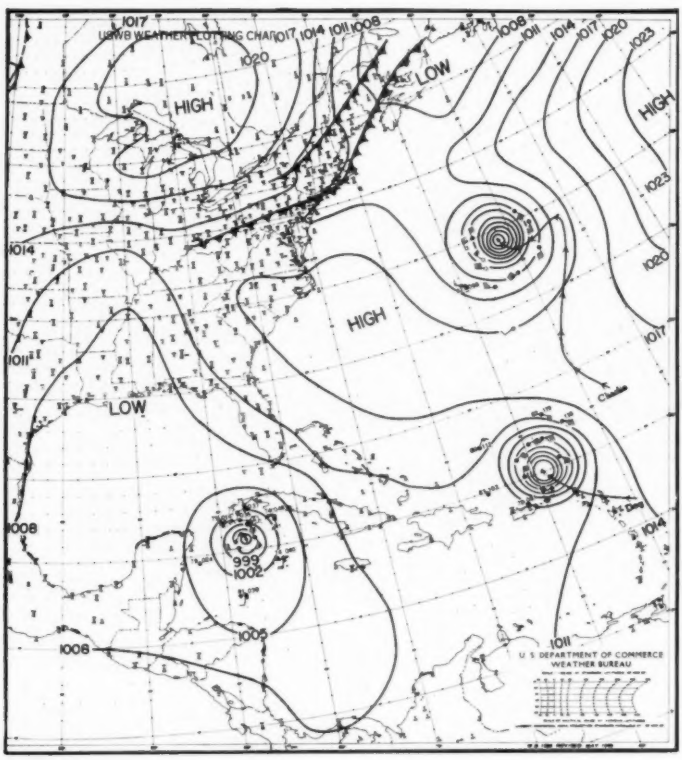
Other factors for formation undoubtedly exist, but remain as subjects for further study.

Hurricane Detection

The general synoptic situations which have been found to be favorable for hurricane formation are obvious features to be used in hurricane hunting. In addition, tropical forecasters have learned to be on the lookout for special clues. The following surface criteria are given by one of the pioneers in the recent advance of tropical meteorology, Gordon Dunn, of the Weather Bureau, a former member of the staff of the Institute of Tropical Meteorology.

Pressure Observations. Diurnal pressure changes in the tropics are so large that other variations in pressure are often obscured. As a result, 3-hour pressure changes seldom have

(Continued on page 87)



A section of the surface chart for 0730 EST, September 2, 1950, showing three fully developed hurricanes, two in the Atlantic Ocean and one south of Cuba. Reproduced from the *Monthly Weather Review*, January, 1951.

FLOOD DISASTER IN KANSAS

THE heaviest monthly rainfall on record fell during June, 1951, throughout the entire state of Kansas and prepared the way for the greatest flood disaster in the history of communities along the Kansas and lower Missouri valleys. As of July 17th, 23 persons were dead, thousands were homeless, two million acres were under water, and property damage amounted to 750 million dollars.

During most of the month of June and early July a stationary front, separating cold, polar air from Canada and warm, tropical air of Gulf of Mexico origin, extended east and west across Kansas. Rainfall to the north of this front was exceptionally heavy. The average precipitation for the entire state in June was 9.60 inches, which is 5.63 inches above the normal. Rain fell on as many as 22 days, and only one station in the entire state missed equaling the normal figures for rainfall. The greatest amount fell at Climax, Greenwood County, in southeastern Kansas, where the total rain was 16.50 inches.

The temperature, too, was abnormal. The mean for the state was 68.6° F., a deficit of 5.2° F. below normal. During the first days of the month, below freezing temperatures were recorded, but failed to equal the all-time low of 30° F. by one degree. On the other hand, only one station reported a high of 100° F., a very unusual circumstance for

(Continued on page 83)

A July 14th aerial photograph of the cities where the Kansas River (foreground) and the Missouri River (middle background) join. Their confluence is outside the picture to the left. The view is from the Kansas City, Kansas, side, across the packinghouse and warehouse districts to the skyline of Kansas City, Missouri. At the left is the intercity viaduct. Note the level of the water under the bridge at the right. The picture was made by Sol Studna of the Kansas City *Star*. Wide World photograph.

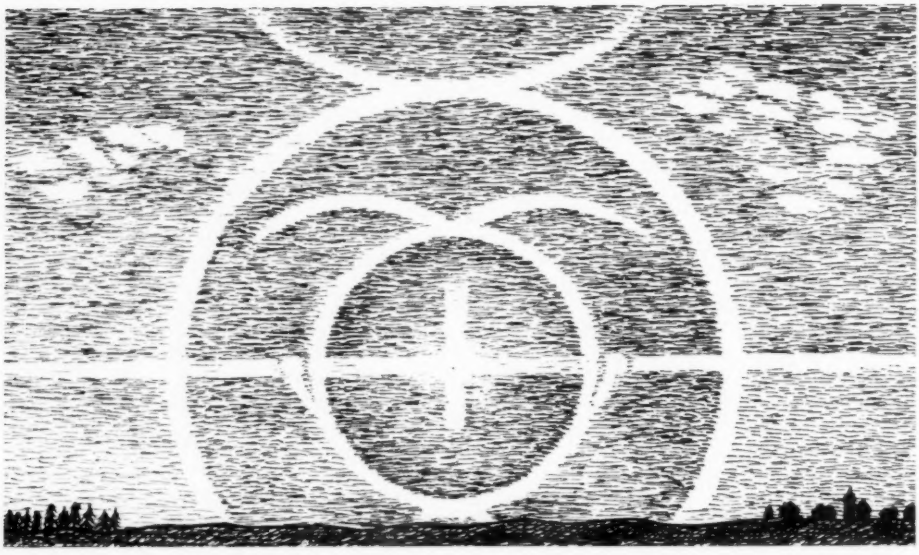


Fig. 1. A schematic diagram of various halo forms, by the author.

HALOS

HANS H. NEUBERGER, THE PENNSYLVANIA STATE COLLEGE

MANY historical instances are recorded in which atmospheric optical phenomena have changed the possible course of events, because people believed them to be the signs of divine warning or encouragement. Probably the interpretation of such signs was governed, at least in part, by the intentions of the ruling powers. For example, a Roman historian mentions a luminous ring around the sun that appeared in the spectral colors when Octavian marched into Rome after Caesar's death. In retrospect, the historian was easily able to connect this phenomenon with the ensuing political disorders in Rome. More practical in his interpretation was Constantine the Great, who on one of his military expeditions saw a luminous cross with the sun at the center and inspired his soldiers to victory with the order of the day, "in this sign you shall conquer." Morris of Saxony, while besieging Magdeburg on behalf of Charles V, saw three "rainbows" and three suns and lifted the siege. It is important to note, however, that Morris intended to turn against Charles V anyway, so the celestial phenomena were probably as good an excuse as any other to keep the city in the hands of his future allies.

Although the people of today are, in general, superstitious in one way or another, celestial optical phenomena no longer play any role in modern political decisions.

Probably the most frequent of optical phenomena in the sky, which include rainbows and coronas, are halos. The word is derived from the Greek, meaning something circular. However, halo phenomena comprise a great variety of luminous shapes, all of which are produced by the refraction or reflection of sunlight or moonlight by the tiny ice crystals of which the high clouds are composed. For this reason, whenever the region around the sun or moon is covered by cirrus, cirrostratus, and sometimes altostratus, there is a possibility that a halo may appear. Since few people venture to scan the sky in the vicinity of the sun, because of the glare, halos around the moon are more frequently observed. In reality, however, solar halos occur five to seven times as often as lunar halos, chiefly because of the periodic waning of the moon. In order

to give the reader an idea of how many halos a moderately diligent observer can see during the course of a year, the data obtained at the Penn State Meteorological Observatory may

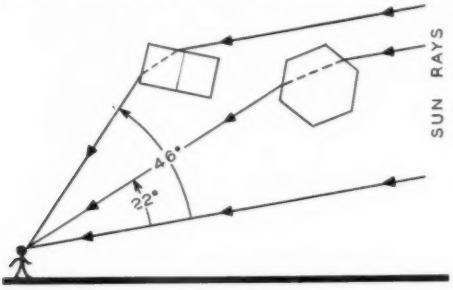


Fig. 2. The paths of light rays through ice crystals, forming the halos of 22° and 46°, respectively.

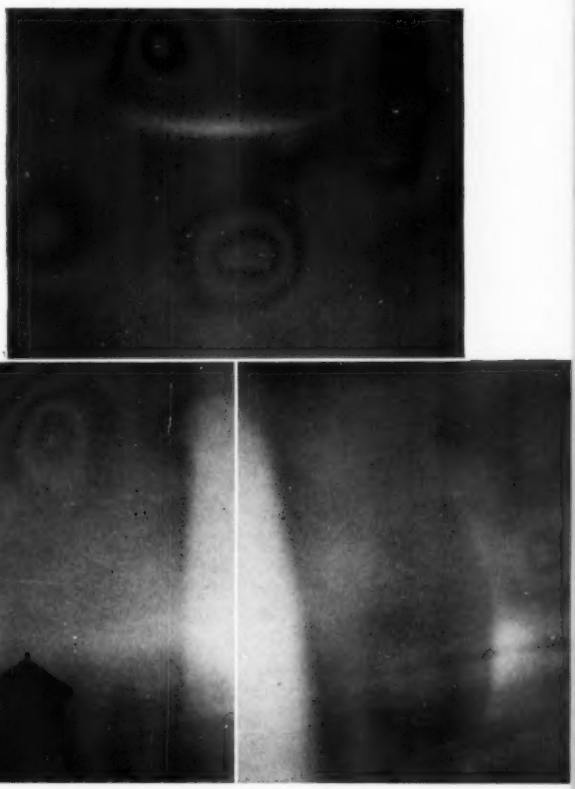
be cited. Here, during the last 16 years, halos were observed on almost 1,200 days, an average of 74 per year. In the year 1938, 145 solar and 24 lunar halos were recorded on 152 days (some solar and lunar halos being observed on the same day).

The sketch shows schematically some of the more frequent halos (Fig. 1). The sun is located in the center of the luminous cross formed by a vertical column called a *sun pillar* and the horizontal band of the *parhelic circle*. This cross is produced by the reflection of sunlight on the surfaces of ice crystals. Since the color of the light is not changed by the process of reflection, these two phenomena, which may occur singly or simultaneously, appear white.

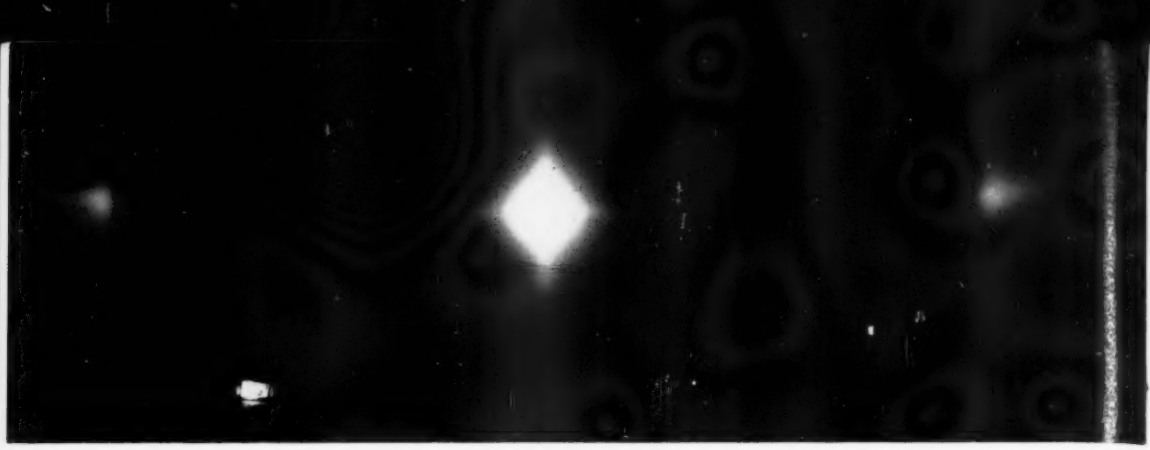
The most frequent individual halo form is the small ring or *halo of 22°*. This ring has an angular radius of 22° — the angle between the sun and the inner rim of the halo at the observer's eye is 22°. In Fig. 1, this halo is shown as the smaller of the two concentric rings around the sun. The large ring or *halo of 46°* is much rarer, although usually more colorful than the halo of 22°.

These two rings are caused by the refraction of sunlight on hexagonal platelets or columns of ice, oriented at random. The path of the light rays through the crystals is schematically shown in Fig. 2. Three sun rays are shown, the lowest one coming directly to the observer; the one in the middle strikes a hexagonal platelet, is refracted by it, and subsequently reaches the observer. When the path through the crystal is symmetrical as shown, the intensity of the light emerging from the crystal is at a maximum, and the deflection of the light ray at a minimum, namely, 22°.

In the case of the halo of 46°, the light



A 22° halo complex with sundogs and a circumzenithal arc, photographed by William Nussbaum at Stamford, Connecticut, January 27, 1948, about 9:30 a.m. EST. The bright central band is spurious, caused by reflections in the camera from the sun's glare.



The moon and mock moons, a composite photograph by Theodore Skonnard, Fargo, North Dakota, January 24, 1951, 3-second exposures on Kodak Super-Panchro Press at f/5.6. The 22° halo was visible, but did not register on the film. The mock moons were colored.

rays enter the top of the crystal (shown by the uppermost ray in Fig. 2) and after refraction leave the crystal through one side. Here, the minimum deflection angle is 46°. Because of the random arrangement of all such crystals, the light rays, thus refracted, form a circle with a radius corresponding to the angle of minimum deflection.

During the refraction process white light is separated into colors, just as a glass prism causes white light to be broken up into its spectral components. Blue light is refracted more than red light, and therefore appears at the outer border of the halo, while red is seen on the inside. However, the coloring of halos is generally faint; most often only a slightly reddish or orange tint is visible along the inner border of the rings.

Refer again to Fig. 1. The bright spots slightly outside the halo of 22° are the *parhelia* or sundogs which belong to the most distinctly colored halos. Short, slanting arcs, called *arcs of Lowitz*, sometimes extend from the parhelia to the halo of 22°, as also shown in Fig. 1. The distance of the sundogs varies with the sun's elevation; when the sun is at the horizon, the sundogs lie on the halo of 22°, but move away from it as the sun rises.

The "wings" on top of the halo of 22° represent the *upper tangent arc* of this halo, or *circumscribed halo*. The latter name comes from the fact that this halo undergoes a metamorphosis as the sun changes its elevation. At low sun, two sets of arcs touch the top and bottom of the halo of 22° (in Fig. 1 the lower portion is just indicated, its greater parts lying below the horizon). As the sun rises higher, the upper wings droop more and more, while the lower set of arcs is lifted, until finally both meet to form a kidney-shaped (later oval-shaped) band circumscribing the halo of 22° and in contact with it at the top and bottom.

The topmost arc touching the apex of the halo of 46° is called the *circumzenithal arc*, because its center of curvature lies at the zenith.

The halos described are only a few of the many forms that occasionally appear in the sky, not only in the region around the sun, but also around the point opposite the sun.

Aside from the aesthetic aspect of halos, there is a certain practical significance attached to them. The proverb stating that "rings around sun or moon forebode rain" has a basis in fact, at least to some extent. Halos certainly indicate the presence of ice crystal clouds, which in many cases are the forerunners of approaching warm fronts. The connection between halos and warm fronts is

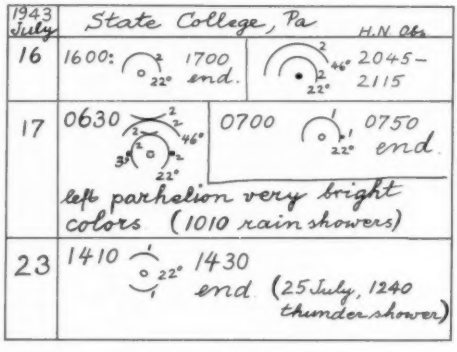


Fig. 3. A sample halo observation record.

a function of climate and season. For example, at State College, Pennsylvania, precipitation occurs within 48 hours, after a halo is observed, in 77 per cent of the cases. This frequency varies with the seasons as shown in the table of the relative frequency of precipitation within 48 hours after days with halos and those without, at State College, Pennsylvania.*

Season	*Halo Days*	*Non-halo Days*
Spring	76%	54%
Summer	69%	48%
Autumn	77%	42%
Winter	87%	58%
Year	77%	50%

It is evident that the probability of precipitation after a halo is greatest in winter, least in summer. However, the greatest increase above normal expectancy of rain occurs in autumn.

Through observations, particularly of unusual halo phenomena, the members of the Amateur Weathermen of America can make valuable contributions to this branch of meteorological optics, and indirectly to the knowledge of the properties of ice-crystal clouds. Many older reports of rare phenomena have never been confirmed, and some theoretically computed halo forms have never been observed. For those who wish to participate in a program of halo observations, such as has been carried on in Europe for many years, here are some pointers:

All-important are the date, the time of the day, and the geographic location of the observer. Although the elevation of the sun can be computed from these quantities, a measurement of the sun's altitude is helpful. The phenomena visible are preferably sketched as shown in Fig. 3. Solar and lunar halos can be distinguished by showing the sun as a circle, the moon as a dot. The degree of intensity of the phenomenon can be marked on the pertinent sketch portions by the numbers *1* for faint, *2* for medium, and *3* for brilliant halos. In order to determine the positions of the various halos relative to the sun, the observer can easily construct a device for measuring visual angles, using a smoked glass or overexposed photographic film to cut out the glare from the sun.

One word of caution: Exaggeration of the extent of halos, their colors, or their brilliancy serves no purpose and makes observations useless for scientific purposes. It is particularly important that halo records show only *simultaneous* phenomena in the same sketch; for example, when first a halo of 22° is visible, and after it has disappeared a sun pillar occurs, two separate sketches must be made and the appropriate times indicated thereon.

At the end of a calendar year, original records, or copies of them, may be sent to the author, Division of Meteorology, School of Mineral Industries, State College, Pa., or to Herbert A. Luft, 42-10 82nd Street, Elmhurst, L.I., N.Y.

*Neuberger, H., Forecasting Significance of Halos in Proverb and Statistics. **Bull. Am. Meteor. Soc., 22,** March, 1941, 105-108.

FLOOD DISASTER IN KANSAS

(Continued from page 79)

the Sunflower State. Hail and tornadoes were unusually numerous and severe, to add to the economic distress in the flood area.

There have been floods before in Kansas, but never have they been for so prolonged a period. A new outbreak of rain during the second week of July brought on a major disaster. The new rains ran off the water-sodden fields into streams, the streams poured their waters into the main rivers, and the rivers overflowed and breached dikes that had withstood many previous floods. The cities of Manhattan, Topeka, and Lawrence on the Kansas River, and the twin cities at the juncture of the Kansas and Missouri rivers bore the brunt of the flood as their industrial and communication systems were paralyzed. The president of the United States made a special airplane trip to inspect the disaster area, and Congress passed an emergency aid bill for 25 million dollars. R. A. Garrett, section director for Kansas of the U. S. Weather Bureau, stated in a report:

"In addition to the loss mainly attributed to storms and floods, the following items indicate extensive damages resulting from the heavy rains and protracted wet weather: replanting of corn and grain sorghums, prevention of cultivation with consequent weedy fields, lodging and shattering of wheat, many acres in western Kansas out of production by water-covered fields, highway and rail traffic impeded, time lost from work, mail delays, and tremendous soil erosion."

The Annular Eclipse of September 1st

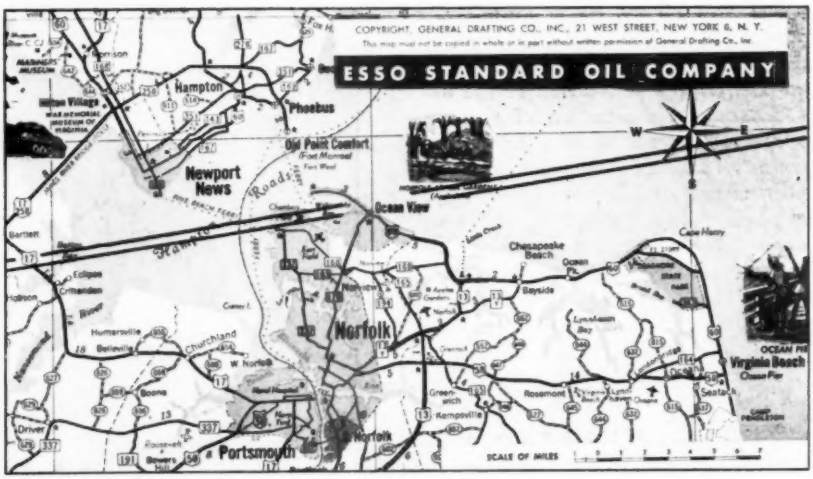
WATCH the sun rise on September 1st, the Saturday of Labor Day weekend. If you live in the eastern half of the United States and Canada, you will observe that the new moon is partially eclipsing the rising sun. During the next half hour or hour, the moon will slide across the sun, producing unusual and peculiar effects, both in the appearance of the sun itself and in the changing illumination of the morning light. The partial eclipse will have its greatest magnitude for those living along the Atlantic Coast, and in eastern Maine the entire phenomenon will occur after sunrise.

For some of the cities in the United States, the percentage of the sun's diameter that will be covered by the moon at maximum eclipse is given here. Figures in parentheses indicate that maximum eclipse will be already over at sunrise; in such cases, the magnitude of the eclipse at sunrise is given. This information is from the *American Ephemeris and Nautical Almanac*.

Albany, N. Y., 82%; Augusta, Me., 78%; Cambridge, Mass., 83%; Cleveland, Ohio, 90%; Lake Angelus, Mich., 79%; New York, N. Y., 87%; Omaha, Neb., (22%); St. Louis, Mo., (52%); Syracuse, N. Y., 80%; Tallahassee, Fla., (68%); Washington, D.C., 92%; Williams Bay, Wis., (66%).

Shortly before 6:00 a.m. Eastern standard time, observers within a 95-mile band extending from the mountains of North Carolina to the sea coast in the Norfolk, Virginia, area will see the entire moon's disk in front of the sun. The eclipse will not be total, however, for on this occasion the moon is near the farthest point in its orbit and it appears too small to cover the sun completely. At mid-eclipse, along the central line, around the dark moon there remains a thin but brilliant ring or *annulus* of sunlight. This is so bright that it blots out the much fainter light of the sun's outer atmosphere, the corona, which can ordinarily be seen only during a total eclipse of the sun.

Nevertheless, those who are in the path of the annular phase of this eclipse will see an impressive sight. The width of the ring will be only four per cent of the sun's radius. Off



The Norfolk-Virginia Beach area, with the central half mile of the path marked by the double line. The longitude of Cape Henry is 76° 00′ west; Ocean View, 76° 15′ west; Crittenden, 76° 30′ west. The latitude of Old Point Comfort is 37° 00′ north. Reproduced by courtesy of Esso Standard Oil Co. and General Drafting Co., Inc.

The annular eclipse of April 7, 1940, photographed at San Marcos, Texas, by Robert Brown. A 4½-inch refracting telescope of 60 inches focal length produced images the size of those shown here. A heavy neutral-density filter was used behind the lens, and the exposures were 1/100 second on Panatomic-X film. The ring at the left is not quite perfect, as the camera was located about three miles south of the central line of the annular path. On September 1st, the ring will be much thinner than it appears here.

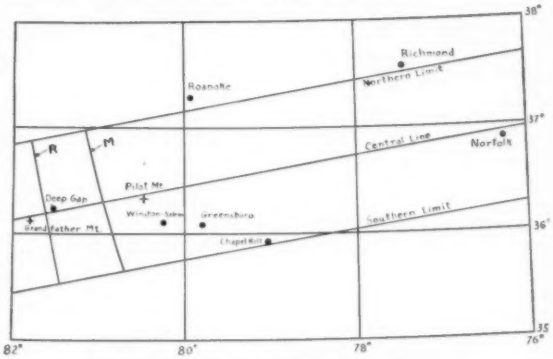
the central line, the ring will appear displaced north or south on the sun, not perfectly round, and the duration of the annular phase will be less than its maximum of two minutes, 40 seconds, in the center of the path.

At Norfolk, the sun will rise about 25 minutes before mid-eclipse, and it will have an altitude of about four degrees during the annular phase. This is the most favorable region in the United States from which to observe the annular eclipse. Farther west, the ring phase will occur closer to sunrise, until on the western limit of the annular path the sun will rise as a ring of light. Observers on elevations, such as Pilot Mountain in North Carolina, can gain a considerable advantage in sunrise time because of the dip of the horizon.

During the annular eclipse, some of the brightest stars may be visible, and binoculars may aid detection of hydrogen prominences on the edge of the sun just as the moon moves on and off. Photographs may be taken, with and without filters, but exposure times will vary greatly with local atmospheric conditions. The image of the eclipse on ordinary short-focus hand cameras will be very small. Cameras should be mounted on tripods for steadiness, and those with reflex attachments may be used to position on a single camera frame a series of exposures showing the progress of the eclipse. Kodachrome, properly exposed, will record the color changes of the eclipsed dawn.

Because the corona is not seen, an annular eclipse is of relatively small scientific value, and professional astronomers will not travel thousands of miles to get within the 95-mile path in North Carolina and Virginia. Radio astronomers, however, can utilize both the partial and annular phases to study the sun's radio spectrum and to measure properties of the ionospheric layers of the earth's atmosphere. They will be able to make most of their observations even if the sky is cloudy.

Thousands of amateur astronomers are expected to observe the annular eclipse. Immediately afterward, many of them will trav-

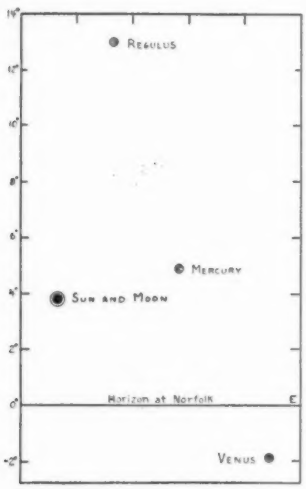


The limits of the path of the annulus on September 1st. The line marked "M" shows where mid-eclipse occurs at sunrise (upper limb), but this line is actually farther west, as at "R," when the size of the solar disk and refraction by the atmosphere are taken into account. Diagram by Paul W. Stevens, Rochester, New York.

On June 9, 1945, the phases of a partial eclipse at Philadelphia were photographed on one frame by Dr. George Rosengarten. This same eclipse was total in Montana and Saskatchewan.

el to the University of North Carolina at Chapel Hill, where the Astronomical League will hold its annual general convention on September 1-3. Amateur Weathermen of America members and other amateur and professional meteorologists are also invited to attend. Information can be obtained from the convention chairman, G. R. Wright, 202 Piping Rock Drive, Silver Spring, Maryland. The eclipse will be an important theme of this convention, which will also feature simulated observing of stars in the Morehead Planetarium.

Weather is always of extreme importance at any eclipse. Amateur weathermen, whether they plan to observe within the path of the annular phase or elsewhere, may want to carry out "rehearsals" of sunrise from vantage points a few mornings before the eclipse. The sun will rise generally nine or 10 degrees north of the east point of the horizon. Special weather broadcasts to serve observers within the annular path are being arranged, particularly those described on page 74.



The sun and moon will be about four degrees above the horizon at Norfolk at mid-eclipse. Venus will not have risen, but Mercury and the star Regulus may possibly be observed during the annular phase. Diagram by Paul W. Stevens, Rochester, New York.

Prospects for clear skies are relatively good along the path of the annular eclipse. Early morning fog is always a hazard, possibly more serious in the mountains than along the coast, where "settled" dry conditions mostly prevail early in September. Every kind of weather is possible at eclipse time, including the effect of a late August hurricane moving up the Atlantic Coast. Fortunately, the brilliance of the annular eclipse will make it visible even through cirrus clouds and haze.

The illustrations with this article are reproduced from the magazine *Sky and Telescope*. C. A. F.

SAFE FLYING

Weather is still the most important factor both in limiting the use of small aircraft and in causing accidents in private flying. The Aviation Safety Center of Cornell University, in its first annual report, has stated that the weather factor accounts for 15 per cent of all fatal accidents in aircraft. Totals vary considerably through the United States, with some sections reporting zero accidents due to weather while in others the ratio runs as high as 50 per cent.

In an effort to distribute weather information to aircraft more rapidly and efficiently, the U. S. Weather Bureau at LaGuardia Field, New York, has inaugurated a test broadcast of continuous weather information by means of a tape recorder. The frequency employed is 162.550 megacycles.

THE ORIGIN AND DETECTION OF HURRICANES

(Continued from page 78)

useful application in such regions, but by use of the 24-hour pressure change, the diurnal effect is eliminated. A 24-hour pressure fall of three to 3.5 millibars or more is a danger sign that a tropical storm may be developing. Also, if surface pressures five or more millibars below normal are observed on the map, the forecaster is on his guard.

Wind Observations. Surface wind observations at tropical land stations are notoriously unrepresentative of synoptic conditions. The land- and sea-breeze effect is an important phenomenon at coastal stations. Orographic distortions of the wind flow are very great in mountainous country. These facts allowed for, easterly wind observations 25 per cent and more above normal intensity in a limited area, especially when the flow curvature is cyclonic, are danger signals for the tropical forecaster. Where the surface trade winds are normally easterly, any observed wind direction from south through west to north is another condition to be watched.

Weather Observations. Clouds and precipitation, especially showers, at land stations are mostly a matter of the topography, except when synoptic systems are involved. Unusually heavy precipitation or steady rain, instead of the usual shower type, at several neighboring stations are clues to abnormal tropical weather. Also, cirrostratus or altostratus overcast conditions reported at several nearby stations indicate possible trouble spots.

Sea Swell and Tide Observations. Danger signals for tropical storms also include an ocean swell with a shorter than average period and an amplitude greater than normal. The average swell frequency is eight per minute in the Atlantic and 14 per minute in the Gulf of Mexico. Hurricane winds set up swells with frequencies of only four per minute. Swells will approach approximately from the direction in which the storm is located. The amplitude of the swell is an indicator of the storm intensity, especially when the swells have not entered shallow water before reaching shore. Abnormally high tides along broad coastlines and shores of partially enclosed water bodies are often produced by tropical storms. The highest tide usually is to the right of the path of the storm.

If several, or all of these indicators appear together, there is a high probability that a tropical storm is in existence. The hurricane forecasters watch for such signs in alerting and dispatching reconnaissance planes. One of the main improvements in day-to-day hurricane forecasting is the utilization of aerial reconnaissance in the location and observation of tropical storms.

ED. NOTE: The reader of the foregoing article may wish to review in two earlier issues of WEATHERWISE articles that discuss the hurricane: August 1948, *Huracan — Evil Spirit of the Tropics*, by I. R. Tannehill, and *Finding and Tracking the Hurricane*, by M. L. Blanc and E. Carson. August, 1949, *Hunting Hurricanes with the Seismograph*, by M. H. Gilmore, and *Boxing the Hurricane*.

AMS CODE OF ETHICS

The American Meteorological Society, by a vote of 1377 to 94, has approved a code of ethics for its members. In four parts, it concerns the meteorologist's relations with the profession as a whole, with fellow meteorologists, with clients and the general public, and with the national weather service.

The meteorologist is expected to keep abreast of current developments in his field, and to present his new findings through the media of technical or scientific publications or meetings. He should not engage in unfair competition with his fellow meteorologists, and should give proper credit for original work.

Concerning meteorology's close association with commerce, industry, and the general public, the code reads:

1. The meteorologist will base his practice on sound scientific principles.
2. He will refuse to engage in practices which are generally recognized as being detrimental to the public welfare.
3. He will refuse to undertake, for compensation, work which he believes would be unprofitable to a client without first advising him as to the improbability of successful results.
4. He will make every effort to discourage sensationalism, exaggeration and unwarranted statements concerning the field of his profession, and will refrain from making unwarranted claims.

In relation to the national weather service, members of the AMS should be guided by the policy of the society concerning private practices and the basic functions of government in meteorology.

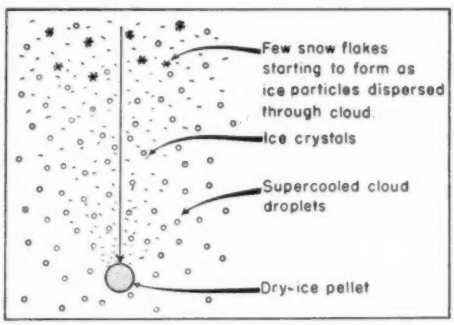
Increasing Precipitation Through Cloud Seeding

ROBERT D. ELLIOTT, NORTH AMERICAN WEATHER CONSULTANTS

CLOUDS form where rising currents, which are always present in storms, lift the lower, moisture-laden air to high regions where temperatures are low. Small droplets less than a thousandth of an inch in diameter develop by condensation. The droplets thus formed are ordinarily too small to descend as rain, but updrafts usually lift them to heights where the temperature is well below 32° F., yet they do not freeze. This phenomenon is known as supercooling.

Suppose a small ice crystal were introduced into such a cloud. It would have the property of removing moisture from all supercooled droplets coming near to it. This is because the water-vapor pressure over ice is much less than that over a supercooled cloud droplet. For this reason, the ice crystal eventually grows to snowflake size and descends. Upon encountering the warmer air of the lower levels it melts and becomes a raindrop.

Ice crystals thus serve as nuclei upon which supercooled water droplets freeze. Ice crystals form naturally at about −40° F. However, most cloud tops do not reach the high level at which such a low temperature exists. If such a height is not attained, the cloud is not self-nucleating and rain does not occur. The theory that postulates the need for ice crystals to be present before precipitation can develop is known as the Bergeron-Findeisen ice-crystal theory. It is well substantiated by facts, although other processes can produce precipitation also, particularly in the tropics.


Few snow flakes starting to form as ice particles dispersed through cloud.
Ice crystals
Supercooled cloud droplets
Dry-ice pellet

A schematic diagram of the effect of dropping dry ice into a cloud of supercooled droplets.

When a dry-ice pellet is dropped into a supercooled cloud, a thin layer of air and the cloud droplets close to the falling pellet are chilled below the critical −40° F. and ice crystals are formed. These are in turn spread by turbulent air motions throughout the cloud, and they may nucleate the entire cloud so that precipitation can occur.

The term "cloud seeding" was introduced by members of the General Electric Research Laboratories, who conducted most of the fundamental scientific research concerning this subject. They have found that minute silver iodide smoke crystals, which are structurally similar to ice crystals, will also serve as nuclei. Dr. Irving Langmuir states that one milligram weight of silver iodide is enough to seed a cubic mile of cloudy air.

The silver iodide smoke generator was developed by Dr. B. Vonnegut. The silver iodide in solid form or in solution is heated to about 1,500° C., at which point it is appreciably vaporized. The vapor is passed rapidly into the cooler surrounding air and is "quenched." As a result of this quenching process, a swarm of small smoke crystals of submicroscopic size is formed; the smoke is nearly invisible.

In the smoke generator shown in the accompanying photograph, silver iodide in acetone solution is fed to the burner under pressure and burned in a propane flame. About 10 trillion smoke crystals are produced in a second by this generator.

Certain types of dust and small soil particles serve as nuclei at temperatures between −15° F. and −40° F. These are often found at great heights, being carried there by updrafts just as silver iodide smoke is carried aloft from a generator placed on the ground. Since there usually exist many clouds whose tops do not extend even to the −15° level, these natural nuclei, although they may be present, are not as effective in starting the precipitation process as is silver iodide smoke or dry ice, for these can operate at higher temperatures.

In this smoke generator, silver iodide in acetone solution is stored in the tank and fed to the propane burner under pressure.

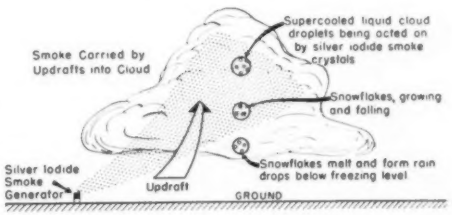
Overseeding can occur. If so many nuclei are introduced into a cloud that there is one for every supercooled cloud droplet, one droplet freezes on each nucleus and a swarm of small ice needles results. These are much too small to descend with any appreciable sinking velocity, and therefore they may float away as a cirrus cloud. In this case the chances for precipitation are greatly reduced, and storm rainfall or snowfall may be less than what would have occurred naturally had there been no seeding at all. It has been computed that there should be no more than one nucleus for every thousand water droplets in order to insure growth to snowflake size.

The introduction of silver iodide directly into a supercooled cloud from an airplane or a ground generator operated at temperatures well below freezing results in immediate local overseeding. If this occurs in the lower part of the cloud, the ice crystals thus formed, and the excess smoke crystals, will be diffused upward through the higher portions of the cloud mass and will eventually attain proper concentrations, with resultant snowflake development.

If the smoke is introduced into the top part of such a cloud, however, the particles are not sufficiently diffused and the cloud top may blow off as an ice veil. In this case an appreciable reduction in precipitation occurs. It has been observed that the ice veil is often carried downwind by stronger winds at higher levels, with respect to lower cloud masses. Virga-like appendages develop which seed the supercooled clouds in the downwind area. Under such circumstances appreciable precipitation increases have been noted 20 to 60 miles downwind. Overseeding of this type by airplane might be avoided by cutting the smoke output several millionfold, but it would theoretically take years to seed at such reduced concentration a drainage basin that ordinarily might be seeded in a few hours.

When a ground generator is operated in conjunction with supercooled clouds with the temperature a few degrees below freezing, snow commences to fall at and immediately downwind from the generator site. When the generator is turned off, the snow ceases. This local phenomenon occurs because silver iodide crystals are slow to act as nuclei at, say, 22° F., and the vast majority of the crystals issuing from the generator do not have time to react until the smoke is carried on to higher levels. Therefore, initially a very small percentage of nuclei are effective right at and immediately downwind from the generator site, and concentrations of active nuclei are correct for growth to snowflake size.

Data from several thousands of hours of operational cloud seeding (most of it unpublished) form the basis for certain conclusions concerning cloud seeding. Some of the results appear contradictory. Precipitation can be increased with the dry ice if it is injected into the right part of the cloud at the right time. On the other hand, it is very easy to overseed certain cloud forms, such as summer cumuli. It has been found that


Supercooled liquid cloud droplets being acted on by silver iodide smoke crystals
Smoke Carried by Updrafts into Cloud
Snowflakes, growing and falling
Snowflakes melt and form rain drops below freezing level
Silver Iodide Smoke Generator
Updraft
GROUND

A schematic diagram of the effect of silver iodide smoke crystals on a supercooled cloud.

silver iodide seeding from the ground and air has the ability to increase the natural precipitation over a region 40 miles wide and 150 miles long, but the area of effect is usually smaller than this. In the center of this area, the natural precipitation is often more than doubled.

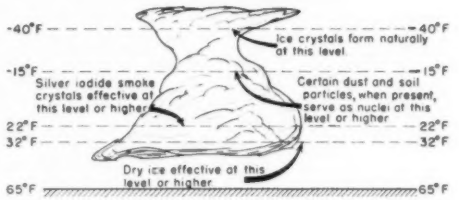
The shape of the area differs greatly under varying meteorological and topographic conditions. With high winds the maximum effect is farther downwind than with light winds. The proper generator location depends on the wind pattern at various levels, which may vary from storm to storm and during the course of a particular storm. When the freezing level is low, close to the generator, the effect is relatively close by; when the freezing level is high, the maximum effect is farther downwind. Under turbulent air conditions, maximum effect occurs close by; it is farther away under stable conditions. In mountainous regions it is much closer by, for in such terrain the updrafts are strong and serve to diffuse the smoke rapidly to high levels.

Of great importance is that the correct cloud types in the required thickness be present. Thus, it is seen that operating the generators so as to hit the target area and not to overseed is difficult. This work should not be undertaken except under the guidance of a competent meteorologist versed in cloud-seeding techniques and having at hand complete weather reports covering an extended area.

Available evidence indicates that precipitation downwind from the area of increased precipitation is not appreciably lessened. This is quite logical for physical reasons. A tremendous amount of moisture passes overhead in liquid, gaseous, and solid forms. Less than one per cent normally falls out as natural precipitation in an area the size of that affected by cloud seeding. The seeding might remove another one per cent, but this is soon made up downwind by lateral mixing with neighboring air masses.

Cloud seeding can do more than merely trigger the release of the liquid moisture held within clouds — it can start the generation of more liquid moisture to replace that removed. Heat is released when the supercooled water droplets are transformed into snowflakes. This heating is enough to cause the air of the cloud to become lighter than the surrounding air mass. The cloud is therefore impelled to rise, more moist air being brought up to the condensation level. Often the induced updraft exceeds in strength previous updrafts and the cloud top rises to higher levels, perhaps even to the −40° F. level, where nucleation can occur naturally.

Because of the natural erratic local variations in precipitation, it is very difficult to evaluate cloud-seeding operations. However, mathematical methods have been developed which establish the overall effectiveness of cloud seeding. For such evaluations, of course, a careful statistical analysis of historical weather records is required.



The levels in the atmosphere at which the various types of seeding processes become effective.

RAINMAKERS' FLOOD?

Dr. Francis W. Reichelderfer, chief of the Weather Bureau, said during the height of the Kansas-Missouri flood that his agency did not believe that the rainmaking in the West caused the recent floods. Disputing a theory suggested by several western senators, Dr. Reichelderfer indicated that his bureau had some definite data to show that rainmakers had little if any connection with the heavy rains in the Middle West. They were traced to a source in the Gulf of Mexico.

At the same time, Dr. Irving Krick, the foremost rainmaker in the West, stated, "It was impossible that our activities had anything to do with the floods in Kansas and Missouri. Our generators had been out of action for several weeks, due to lack of clouds, and we only resumed cloud seeding on July 13th in New Mexico."

Senators from the Missouri Valley have been calling for quick action on the federal weather control bill and on the proposed Missouri Valley authority, which would form a regional plan for overall flood control.

A Record June Snowstorm at Calgary, Alberta*

A. F. McQUARRIE AND C. PICKERING

METEOROLOGICAL SERVICE OF CANADA

DURING the first days in June, the weather on the Canadian prairies was generally good but cool, except for showery conditions near the foothills of the Rockies. The northern states of the United States, on the other hand, had everything from drizzle through rain and snow to thundershowers. All this was in the wake of a polar cold front, which by June 4th lay from northern Alaska southeastward along the Rocky Mountains to the Gulf of Mexico, thence northeastward to the Gulf of St. Lawrence.

By noon, June 5th, another polar cold front had pushed southward; it extended from near Ft. Nelson, British Columbia, southward and eastward to a depression near Sheridan, Wyoming, thence east-northeastward to the Great Lakes. A Pacific cold front extended from near Burbank, California, through the depression and northwest to near Calgary as an upper front. A cold low aloft, instead of continuing southeastward, remained almost stationary in the Calgary area. At the same time, a secondary surface depression formed near Medicine Hat, Manitoba, 160 miles southeast of Calgary.

The circulation around this depression gave increasing northeast and north winds which resulted in "upslope" weather along the eastern slopes of the Rockies. Besides the low clouds caused by this effect, there was considerable cloudiness due to the overrunning along the frontal surface itself. Clouds in the Calgary area were based about 400 feet above the surface and were topped about 21,000 feet (mean sea level), with any layers merged in precipitation into one solid mass.

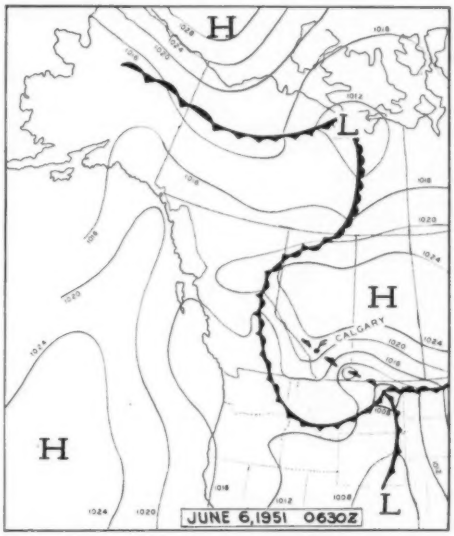
Temperatures at surface levels were hovering at 32° F. — occasionally 33° or 34° F. Almost all of the precipitation fell as snow, but it was very wet and most melted as it fell. At Calgary, five to six inches lay on the ground at one time, although greater amounts fell in the hills to the west. The wet snow froze on power and communication lines in several localities, resulting in many breaks to both wires and poles.

By the evening of June 6th, the weather system began to move eastward, and the next day rapid clearing occurred. By that afternoon the snow had all melted, except for drifts which persisted for several days.

The weather for the four days preceding this unseasonal snowstorm was cloudy, showery, and cool. Temperatures averaged 12 degrees below a normal of 52° F. for the first week in June. Five degrees below freezing was recorded on the 2nd. Winds were generally northerly, at velocities averaging slightly above the normal 10 miles per hour. Thunderstorms of light intensity occurred on the first three days of the month, which was unusual for early June.

The 5th of June began with overcast skies and temperatures in the high 30's. Rain commenced to fall at 5:25 a.m., turning to intermittent rain and wet snow at 6:30 a.m. By 9 o'clock, the rain had ceased and wet snow was falling, restricting the visibility to 1½ miles. The wet snow continued to fall throughout the day with varying intensity sometimes lowering the visibility to ⅜ mile. The snow melted on the ground as it fell. The wind, which had been light easterly when the storm began, backed to northeasterly with gradually increasing speed, at times reaching 20 miles per hour.

The snow continued to fall throughout the evening, and with the falling temperature was beginning to show on the ground for the first



The circumstances of the unusual snowstorm are well illustrated by this chart of the synoptic situation at the surface on June 5-6, 1951. The chart extends from Alaska well into the United States. An occluded zone is situated over Calgary, and there are several small centers of lowest pressure. Chart from the Meteorological Service of Canada.

*Published with the approval of the Controller of the Meteorological Service of Canada.

time. Temperatures dropped steadily, from 39° at the beginning of the storm to 33° at midnight. The wind had now backed to the north, averaging 25 miles per hour. The snow continued to fall all night, and by 5:30 a.m. on the 6th the total amount measured was 6.1 inches. The minimum temperature was 31.8° F. between 1:00 and 4:00 a.m. Wet snow was still falling at noon at the rate of one inch per hour; thus, the total amount measured since the storm began was 12 inches. A further four inches of wet snow was recorded at 5:30 p.m., when the precipitation changed to drizzle.

Although 16 inches of snow fell in 36 hours, the greatest amount measured on the ground at any time was six inches. On the hills two miles west of the station, where temperatures would be one to two degrees lower, the snow measured 12 inches on the level with deep drifts in the coulees. Snow was observed on the hills five days after the end of the storm.

SUMMER SNOW

The plateau and mountain regions of western Canada and the United States have worn a wintry aspect on several recent June and July days. Snow has been unusually persistent this year. Early in June there were several days with snow. Calgary, Alberta, received 16 inches in 36 hours, as described on the preceding page, while to the south, Lander, Wyoming, had a snowfall of 11 inches during the first week of June. There was snow as far east as Rapid City, South Dakota, where the first measurable June snow was reported. As late as June 26th, Calgary was having snow flurries.

Another cold period in July brought heavy falls along the Montana-Wyoming border. On the 11th of the month, 16 inches of snow near Red Lodge, Montana, blocked the northeastern entrance of Yellowstone Park. The local weatherman reported this as just "a normal July snow."

HOW ABOUT THE WEATHER?

Robert Moore Fisher. Harper and Bros., New York, 1951. 186 pages. $3.00.

A TOOL advertised to serve a dual purpose many times proves disappointingly inadequate for either purpose. Occasionally, we come across one that is an exception and that gives us cause for much celebration. Rare, too, are books on technical subjects that will at the same time appeal to the professional and the amateur. **How About the Weather?** is just such a book.

You will enjoy reading about this complicated subject of weather with the assistance of many excellent examples, illustrations, and explanations. On the other hand, you will find the scope of material covered fulfills the requirements of a good standard textbook without the usual tediousness associated with routine school books. The table of contents by chapters illustrates these points:

1. How to Make Your Guess Better than Mine. 2. From Noah to Now. 3. The Atmosphere: the Largest Unexplored Region in the World. 4. Temperature: Mud Pies and Climate. 5. Clouds: Mare's Tails, Ivory Towers, and Tattle-tale Gray Sheets. 6. Pressure and Circulation: Thirty-four Feet More and Less. 7. The Principal Air Masses: Moscow, Trinidad, or Winnipeg? 8. Fronts: the Battle Zones of the Sky. 9. How to Interpret Newspaper Weather Maps. 10. Fog: One Up on Scrooge. 11. Winds: Breezes and Blows. 12. Forecasting the Weather: How To Be Your Own Ground Hog.

The appendices include information on how to estimate the speed of the wind and forecasting guides for the layman. These even have "general rules for guessing." For those of us not professionally trained in meteorology but who have some background in reading weather maps, Chapter 9 is especially good. The sequence of weather maps presented for study is well chosen and clearly explained. This chapter may slow you down a little, but it is well worth the trouble.

To the great majority of us the important question is, "What's the weather forecast?" We haven't up-to-the-minute weather maps nor do we have teletype service. We must look around and see what information is available in the sky. But first we must know just what to look for. After reading this book we should have a pretty fair idea of what to look for and how to interpret it.

There is one recommendation I would like to make for those about to read **How About the Weather?** Start with the last chapter. I know this seems illogical, but I believe it will better organize your thinking and help to minimize any tendency to skip lightly over important information elsewhere in the book.

No matter where you start, I can guarantee that you will know more about the weather than you did before reading this book.

W. S. BURRISS, JR.
Newtown, Pennsylvania

WEATHERWISE BACK ISSUES

For its first three volumes, 1948-1950 inclusive, back numbers of WEATHERWISE are available: 35 cents per copy, $2.00 per volume of six issues, postpaid.

AMATEUR WEATHERMEN OF AMERICA

The Franklin Institute, Philadelphia 3, Pa.

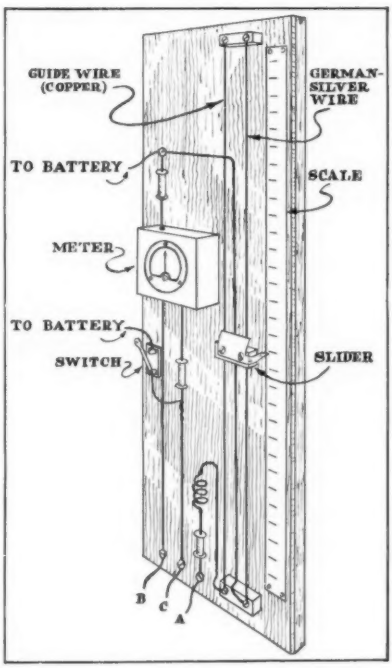
WORKSHOP FOR WEATHERMEN

CONDUCTED BY CHARLES A. LAIRD

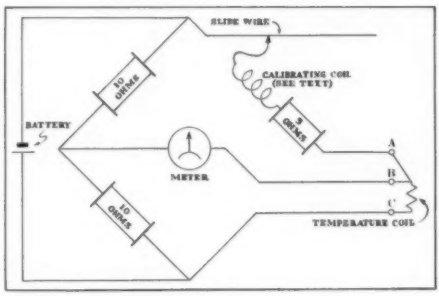
How to Construct a Telethermoscope

IT IS a well-known fact that the electrical resistance of all metals varies with their temperature. If we can measure the resistance of a coil of wire and calibrate this measurement in terms of temperature, we will have a convenient thermometer — convenient because we can determine "temperature at a distance." And that is what the term telethermoscope means.

Commercial telethermoscopes use nickel, platinum, or copper wire for the "bulb." Since nickel is sometimes hard to obtain and platinum is "out of this world" in price, the temperature-measuring coil in the instrument described here consists of 10 feet of No. 40 copper wire. Wind it, skein fashion, on a strip of cardboard about 2″ in length and ¼″ wide. Solder two short lengths of flexible wire, such as radio hookup wire, to one end of the coil and one length of the same type of wire to the other end. Slide this coil into a section of ⅜″ or similar size copper or brass tubing. This section of tubing should be about 3″ long and sealed at one end.



Mounting the telethermoscope. The connecting wires may be placed back of the mounting board if this is desirable.



The Wheatstone bridge assembly.

The lengths of flexible wire should extend outside the tubing; they are used for making connection to the temperature-indicating device. After pushing the coil of copper wire in the tubing, pour in enough paraffin to fill it.

The device used to measure the resistance of the copper coil, and consequently its temperature, is called a Wheatstone bridge. It consists of three fixed resistance coils and one variable one, a battery and a suitable meter. It is suggested that the builder consult a physics textbook to learn the principle upon which the Wheatstone bridge operates. It will suffice here to say that we change the setting on a variable resistance until its resistance matches the resistance of the "bulb." At that point, a current-indicating meter will read zero and the bridge will be in balance. If the variable resistance is calibrated in degrees, you will then know the temperature at the "bulb."

The "bulb."

The wiring diagram and manner of assembling the components are shown in the drawings. You will need two 10-ohm and one 5-ohm resistors. These should be of good quality so they will maintain their resistance. You will also need a meter, such as a 100-0-100 microammeter or a 1-0-1 milliammeter. A 2″ meter is large enough. The resistors, meter, and other components are mounted on a vertical backboard 4½ feet long and 2 feet wide. You can use ¼″ plywood or similar material for this.

A 4-foot piece of No. 26 bare German silver wire is used for the variable resistance, or slide wire. Another 4½-foot length of this same size wire, insulated if possible, is used for a calibrating resistance. In other words, it is used to adjust the final calibration so that the indicating scale covers the desired temperature range. The German silver wire and a 4-foot

length of No. 14 or heavier bare copper wire are mounted on small blocks which are fastened to the backboard, as shown. These wires should be about 2″ apart. A piece of thin copper or brass sheet, shaped as shown, is mounted on a small block which is drilled so that the assembly, called the slider, will slide up and down the parallel wires and make contact between them. This, of course, varies the amount of German silver wire in the circuit and, consequently, its resistance.

The meter is mounted in a small wood or metal box, as shown. One of the small metal meter cabinets, available in most radio parts stores, is ideal for this. A vertical temperature scale, made of heavy cardboard or Bristol board, is mounted on the right side of the backboard, and a pointer, attached to the sliding block, points to the temperature reading.

At 122° F., a coil consisting of 10 feet of No. 40 copper wire will have a resistance of 11.7 ohms. So the leg of the bridge circuit, consisting of the 5-ohm resistor, slide wire, and calibrating coil, must approach this resistance. Wind the 4½-foot length of silver wire into a coil and mount it on the backboard, connecting it in series with the 5-ohm coil and the slide wire, as shown in the diagram. Complete the remainder of the wiring, using No. 16 or heavier radio hookup wire. Ends of wires which will be connected to battery, coil, and so forth, may be fastened to the backboard with wood screws. All electrical connections in this instrument should be carefully soldered.

It may seem strange that two connecting wires run to one side of the bulb. But by connecting the bulb in this manner, any reasonable length of connecting wire may be used, and the temperature of these wires will not affect the indicated reading.

An ordinary dry cell may be used for the battery. It may be mounted on the backboard, if you wish, although it is not shown this way in the drawing. A small switch disconnects the battery when the telethermoscope is not in use.

To calibrate the instrument, connect the bulb to the screw terminals, marked A, B, and C. Obtain an accurate mercury or spirit thermometer covering the scale you desire, and place it in a pan of water with the telethermoscope bulb. Decide what top reading you want your instrument to indicate and heat the water to this temperature. A limit of 115° Fahrenheit will do for most climates. Now push the slider to the top of the scale, making sure the metal contactor is actually making good contact. Close the switch and note the meter reading. If the meter needle is not at zero, indicating a balance, vary the length of German silver wire in the calibrating coil until a balance is obtained. This coil should then be soldered in the circuit.

Now cool the water somewhat, either by adding cold water or a small piece of ice. Move the slider down until a new balance point is found, read the thermometer and place a point on the scale. The calibrating water should be constantly stirred while readings are taken. Repeat the procedure and find more temperature points on the scale of your instrument. You will soon have enough points to divide the scale into degrees. The scale will be linear, so you won't need more than 10 or 12 calibrating points.

For best results, the copper-wire bulb in its protecting tube should be in an instrument shelter such as has been described in WEATHERWISE (February, 1948). If you do not have such a shelter, the bulb may be placed in a constantly shady spot, such as the north side of a building. Three rubber-covered connecting wires may be used between the bulb and the instrument. Or you may obtain a length of three-wire cable. The distance between the bulb and the indicating bridge is not critical.

Here's a chance for every amateur weatherman to add to the accuracy of his hobby! WINDIKATOR — a *precision-built*, pocket-size anemometer — gives exact wind direction, wind velocity at a glance!

Non-magnetic, rust and corrosion resistant, WINDIKATOR is guaranteed accurate. $8.75. Leather belt carrying case $1.50. Model A indicates velocity 5-30 MPH, Model B, 10-60. If your dealer can't supply you, write . . .

The WINDIKATOR COMPANY
120-W Tremont St. Boston 8, Mass.
Export Division: 15 Moore St., New York 4, N.Y.
Cable Address: "Minthorne"

RUNS OF DRY MONTHS

It is more likely that one dry month in a given section will be followed by another than mere chance would indicate, according to the findings published in the **Monthly Weather Review** by U. S. Weather Bureau climatologists C. S. Gilman and J. T. Riedel. Once started, droughts appear to have a tendency to repeat themselves more frequently than they should in the absence of any controlling factor. The lack of weather records of sufficient duration is a serious hindrance in efforts to determine long-range trends by statistical methods.

A WEATHER STATION for AMATEURS

WIND

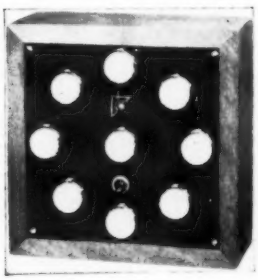
WIND DIRECTION. Electric Wind Vane transmits direction data through eight contact points. **$22.50**

WIND INDICATOR. Eight lights in circle connect to wind vane, center light to anemometer. Complete wind data: direction to 16 points; speed in miles per hour. **$12.50**

WIND SPEED. Electric Anemometer transmits speed data by making contact for each 1/60 mile of wind. **$22.50**

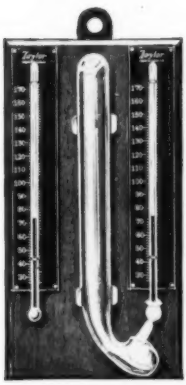
TEMPERATURE

Maximum-minimum thermometer. Four inches in diameter. Easy reset. **$7.95**



COMPLETE WIND SET **$57.50**

HUMIDITY

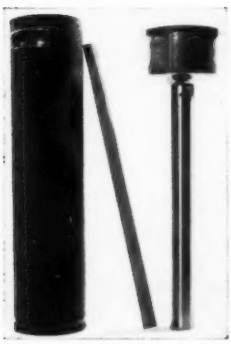


HYGROMETER. Wet and dry bulbs with syphon reservoir. Range 30° to 120° F. **$9.00**

PRESSURE

Baroguide. Reads to .10 inches. Dial five inches in diameter. **$10.00**

RAIN



RAIN GAUGE. Green type. Three inches diameter. 12 inches rainfall capacity. Measuring stick graduated to 1/100". **$7.95**

All Prices F. O. B., Philadelphia, Pa.

Everything for the study and practice of Weather, professional and amateur. Write for catalog.

SCIENCE ASSOCIATES

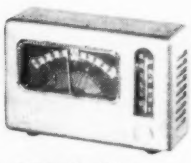
401 North Broad Street, Philadelphia 8, Pa.

Bendix-Friez

Symbol and Source

OF THE WORLD'S FINEST WEATHER INSTRUMENTS

As principal supplier to the Government since 1876 and particularly to the Weather Bureau since its founding in 1891, Bendix-Friez has paralleled the growth of the science of meteorology with its developments in meteorological instrumentation. Thanks to its unique combination of long experience and up-to-the-minute manufacturing facilities, Bendix-Friez stands alone as America's oldest and largest producer of meteorological equipment. Today, Bendix-Friez instruments are recognized as standards of accuracy wherever they are used. *Whatever* your needs for weather data and wherever you need to collect it, Bendix-Friez makes the proper instrument for the purpose.



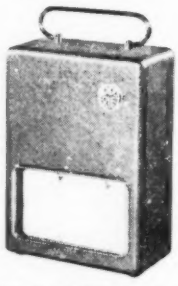
BENDIX-FRIEZ

Hygrodial

Model 185

Precision Humidity and Temperature Indicator

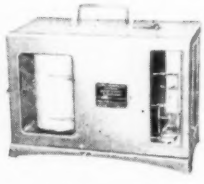
Hair-operated and calibrated to professional standards of accuracy by the maker of the world's finest weather instruments. Handsome, modern case—4" high, 5½" wide, 1⅞" deep.



BENDIX-FRIEZ Model 160

Portable Humidity and Temperature Recorder

3" x 5" charts, 10 or 30 hour records. Modern design . . . handy for small space and difficult locations . . . built to meet unusual conditions.



BENDIX-FRIEZ

Hygrothermograph Model 594

The foremost relative humidity recorder for laboratory, factory, and office use. Scientifically designed for accuracy and dependability.

WRITE: FRIEZ INSTRUMENT DIVISION of Bendix AVIATION CORPORATION

1302 Taylor Avenue • Baltimore 4, Maryland

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N.Y.